

GRASSHOPPER DENSITIES ON GRAZED AND UNGRAZED RANGELAND UNDER DROUGHT CONDITIONS IN SOUTHERN IDAHO

Dennis J. Fielding¹ and Merlyn A. Brusven^{1,2}

ABSTRACT.—Low-density grasshopper populations were sampled at 15 pairs of rangeland sites in south central Idaho. One site of each pair had not been grazed by livestock for at least 10 years. Grazed sites were managed under normal grazing regimes established by the Bureau of Land Management.

Mean grasshopper density was higher on ungrazed sites than on grazed sites. Proportions of *Melanoplus sanguinipes* were higher on ungrazed sites than on grazed sites and were higher on annual grasslands than on other vegetation types. Effects of grazing appeared to be independent of vegetation type.

Proportions of Gomphocerinae, a subfamily of grasshoppers that feeds almost exclusively on grasses, were affected by vegetation type, but not grazing. Crested wheatgrass seedlings supported the highest proportions of Gomphocerinae. Proportions of Oedipodinae were affected by grazing and vegetation type. Higher proportions of Oedipodinae were found on grazed sites than on ungrazed sites, and on sagebrush/grass sites than on annual grasslands. Results indicate that livestock grazing during drought conditions tends to reduce grasshopper populations on southern Idaho rangeland.

Key words: Orthoptera, Acrididae, *Melanoplus sanguinipes*, livestock grazing, drought, population density, range management.

Grasshoppers are frequently the most abundant arthropods, in terms of biomass, in the intermountain sagebrush ecoregion of the western United States. As primary consumers they may be important in energy and nutrient cycling, and, at outbreak densities, they compete with livestock and wildlife for forage. Because of their ecologic and economic importance, the potential effects of range management practices on grasshoppers are a concern to those interested in the health of rangeland ecosystems. Several studies have addressed the role of livestock grazing on grasshopper populations (Coyner 1938, Smith 1940, Campbell et al. 1974, Holmes et al. 1979, Capinera and Sechrist 1982, Jepson-Innes and Bock 1989, Quinn and Walgenbach 1990, Miller and Onsager 1991). Onsager (1987) suggested that there is probably geographic variation in grasshopper responses to grazing among rangeland types and their constituent grasshopper communities. To date no studies have investigated the relationship between livestock grazing and grasshopper densities on rangelands in the intermountain region.

This study, conducted during years of below-normal precipitation and low grasshopper densities, examined differences in grasshopper densities between rangeland under normal

livestock grazing regimes administered by the Bureau of Land Management and rangeland that had not been grazed for at least 10 years.

STUDY AREA

The study area is located southeast of Shoshone, ID, within the Bureau of Land Management's (BLM) Shoshone District, between longitude 114°30' and 114°00' W and latitude 42°37.5' and 43°00' N. This area receives an average of about 26 cm of precipitation annually, most of it between October and May. Average annual temperature is about 9.0°C.

The intermountain sagebrush ecoregion was subjected to heavy grazing pressure in the late 19th and early 20th centuries, frequent fires, and subsequent invasion by cheatgrass and other exotic plant species (Pickford 1932, Stewart and Hull 1949, Mack 1981, Yensen 1982). As a result, stands of grazing-intolerant native grasses were greatly diminished over much of the region, and cheatgrass has become the dominant species on more than 40 million ha of the Intermountain West (Mack 1981, Pellant and Hall 1994). The present vegetation within the study area consists primarily of cheatgrass, *Bromus tectorum* L., with sagebrush, *Artemisia tridentata wyomingensis* Beetle &

¹Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843.

²Author to whom correspondence should be addressed.

Young and *A. tridentata tridentata* (Rydb.) Beetle, where it has not burned recently. As of 1988, about 23% (ca 40,000 ha) of the study area consisted of crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., plantings (USDI-BLM 1984, 1990).

MATERIALS AND METHODS

Ungrazed sites were selected on the basis of grazing history (not grazed for at least 10 years), size (at least 16 ha), and shape (at least 100 m across the narrowest dimension). Fifteen rangeland sites were found within the study area that met these criteria. Most sites were isolated tracts fenced to exclude livestock and to provide habitat for upland game birds. Grazing by wildlife within the ungrazed tracts was negligible. Black-tailed jackrabbits were not abundant during the years in which sampling took place, and populations of pronghorn antelope, the only other large vertebrate herbivore present in the summer, are quite low and widely dispersed across the study area, ca 300 individuals over 180,000 ha (J. Russell, USDI-BLM, personal communication).

A grazed site was selected to match each ungrazed site for a total of 30 sites. In most cases grazed sites were adjacent to, and shared a boundary with, ungrazed sites. For six sites adjacent matched pairs were not possible; consequently, grazed sites were chosen within 2 km. All grazed sites matched the ungrazed sites in soil type, topography, vegetation, slope, and aspect. All grazed sites were located within BLM-administered grazing allotments. Stocking rates for the grazed sites varied from 1.9 to 2.8 ha/AUM (USDI-BLM 1990). Not all grazed sites were grazed each year, as prescribed by rest-rotation grazing management plans.

Elevation of the sites ranged from 1180 to 1320 m. Five pairs of sites were located on areas replanted with crested wheatgrass, four pairs were on annual grassland sites having little or no sagebrush, and six pairs were located on sagebrush-grass sites.

GRASSHOPPER AND VEGETATION SAMPLING.—Grasshoppers were sampled on 19 July–7 August 1990 (adult stage), 21–28 June 1991 (primarily nymphal stage), and 2–13 August 1991 (adult stage). Corresponding sites of a grazed and ungrazed pair were always sampled on the same day. Grasshopper density on

a site was estimated by counting the number of grasshoppers flushed from 50, 0.1-m² rings 5 m apart in a circular transect (Richards and Waloff 1954, Onsager and Henry 1977). Species composition on a site was determined by a "flush-capture" method (Capinera and Sechrist 1982). Thirty to 100 specimens were captured and identified at each site on each sampling date by slowly walking in a circular transect and, to avoid bias toward more conspicuous species, counting only those grasshoppers encountered directly in the path of the observer.

Vegetation was sampled on the same dates as the grasshoppers by visually estimating the percentage ground cover in 5% increments by plant species in each of 40, 0.1-m² square quadrats in a circular transect. Plant species unidentifiable in the field were collected and identified later. The percent cover of cryptogams, cattle dung, and bare ground was also estimated. Vegetation data from the three sampling dates were combined for subsequent analyses.

DATA ANALYSIS.—We classified the sites into three vegetation types based on dominant vegetation on a site. Sites that had been seeded to crested wheatgrass were categorized as replanted. Sites with sagebrush as the dominant plant species were placed in the sagebrush category, and the remaining sites, dominated by cheatgrass without significant sagebrush cover, were categorized as annual grasslands.

Differences in percentage ground cover among vegetation types were confirmed with a Kruskal-Wallis non-parametric one-way analysis of variance (Zar 1984). Non-parametric statistical tests were used with the ground cover data because of the large number of zero values involved. Comparisons between vegetation types were made with a non-parametric analog of Tukey's test (Dunn 1964, Zar 1984).

Because paired sites were in close proximity and of similar vegetation, we used Wilcoxon paired-sample tests to identify differences in percentage ground cover between grazed and ungrazed sites.

Grasshopper densities were too low to conduct meaningful statistical comparisons separately for all species. Accordingly, analyses were conducted on densities of total grasshoppers, on proportions of *Melanoplus sanguinipes* (the major pest species in the region), and on proportions of the three subfamilies of Acrididae within the region, Melanoplinae, Gomphocerinae, and

Oedipodinae. Grasshopper densities were transformed by $\log_e(x + 1)$ to normalize the data. The arcsin transformation was applied to the proportions (Zar 1984).

Three-way analysis of variance (PROC GLM, SAS Inst.) was used to determine the significance of sampling date, vegetation type, and grazing treatment effects on grasshopper density and proportions. For the ANOVA, sites were not blocked by location; i.e., pairing was ignored. Comparisons among vegetation types were made with least significant difference mean separation tests (PROC GLM, SAS Inst.). Paired-sample *t* tests were used for comparisons between grazing treatments.

Trends between habitat characteristics and grasshopper densities/proportions were evaluated by Spearman rank correlations (PROC CORR, SAS Inst.). Mean values from the three sampling dates were used for the correlation analyses.

RESULTS

The replanted vegetation type was dominated by crested wheatgrass and also had the greatest amount of bare ground (Table 1). Annual grasslands were dominated by annual plant species, primarily cheatgrass (Table 1). Sagebrush sites had the greatest shrub cover, although other vegetation types had small amounts of sagebrush (Table 1). Annual grasslands and sagebrush sites had little perennial grass cover, other than *Poa sandbergii*.

Grazing treatment did not greatly affect most ground cover variables (Table 2), but sites grazed by livestock had more bare ground and cattle dung and less total vegetative cover and perennial grass cover than the permanently ungrazed sites.

Twenty-three species of grasshoppers were identified from the 30 sites. *Melanoplus sanguinipes* was found at all 30 sites and represented 36% of all grasshoppers on the study sites. Other common species included *Oedaleonotus enigma* (Scudder), *Ageneotettix deorum* (Scudder), *Aulocara ellioti* (Thomas), *Conozoa sulcifrons* (Scudder), and *Trachyrachys kiowa* (Thomas). No species other than *M. sanguinipes* comprised more than 10% of all grasshoppers from all sites. Total density of grasshoppers on the three sampling dates ranged from <0.2 to 2.6 per m².

TABLE 1. Median (s.d.) percentage ground cover by vegetation type.

Ground cover variables	Vegetation type		
	Replanted (N = 10)	Sagebrush (N = 12)	Annual grasslands (N = 8)
Annual grasses	1.2b ¹ (3.7)	7.8b (8.1)	20.0a (9.0)
Annual forbs	0.5a (1.6)	1.2b (3.9)	3.1b (2.8)
<i>Agropyron cristatum</i>	16.8a (7.2)	0.0b (0.02)	0.0b (0.03)
<i>Poa sandbergii</i>	6.9a (4.9)	5.0a (1.7)	12.0a (5.4)
Other perennial grasses	0.1a (0.4)	0.6a (2.9)	1.1a (2.8)
Sagebrush	0.0b (2.8)	13.0a (5.0)	0.0b (2.4)
Total vegetation	26.1a (8.6)	32.9a (5.7)	41.8b (8.9)
Cryptogams	1.8a (3.2)	7.0b (5.9)	3.1ab (4.3)
Bare ground	40.5a (13.7)	24.0ab (6.5)	18.0b (8.3)

¹Measures within rows followed by different letters are significantly different, *P* < .05, non-parametric analog of Tukey's test (Dunn 1964, Zar 1984).

Total density of grasshoppers was affected by sampling date and grazing treatment (Table 3). No differences in density were detected among vegetation types (LSD mean separation, *P* = .05; Table 3, Fig. 1).

Proportions of *M. sanguinipes* and all species within the subfamily Melanoplinae were affected by sampling date, vegetation type, and grazing treatment (Table 3). Annual grasslands had the highest proportions of *M. sanguinipes* and of all species within the subfamily Melanoplinae (LSD mean separation, *P* = .05; Fig. 1). The proportion of grasshoppers within the subfamily Gomphocerinae was strongly affected by sampling date and vegetation type, but not grazing (Table 3). Replanted (crested wheatgrass) sites had the highest proportions of Gomphocerinae (LSD mean separation, *P* = .05; Fig. 1). Proportions of grasshoppers within the subfamily Oedipodinae were significantly affected by sampling date, vegetation type, and grazing, although F-values were not as great as for proportions of the other subfamilies (Table 3). The mean proportion of

TABLE 2. Comparison of median (s.d.) ground cover between grazed and ungrazed sites.

	Grazing treatment	
	Grazed	Ungrazed
Annual grasses	10.0 (5.5)	7.0 (12.3)
Annual forbs	1.0 (1.9)	1.5 (3.8)
All perennial grasses*	3.0 (6.4)	4.3 (11.3)
<i>Poa sandbergii</i>	8.7 (5.6)	7.1 (4.9)
Sagebrush	3.0 (7.1)	3.0 (6.8)
Total vegetation*	32.5 (7.6)	39.9 (6.3)
Cattle dung ¹	0.7 (0.5)	0.0 (0.0)
Cryptogams	4.6 (5.7)	6.2 (6.3)
Bare ground**	31.0 (13.4)	23.0 (10.2)

¹Because no cattle dung was recorded on the ungrazed sites, no statistical test of significance was performed.

*Measures are significantly different ($P < .05$, Wilcoxon paired-sample test, $N = 15$).

**Measures are significantly different ($P < .01$, Wilcoxon paired-sample test, $N = 15$).

Oedipodinae was greater on sagebrush sites than on annual grassland sites (LSD mean separation, $P = .05$; Fig. 1).

The effect of grazing treatment was consistent across vegetation types and sampling dates for all grasshopper variables (Table 3). Because no significant interactions between date and grazing, or vegetation type and grazing, were detected (Table 3), comparisons of grazing treatments were made across all vegetation types and sampling dates.

Overall density of grasshoppers was greater on ungrazed than on grazed plots (paired-sample t test, $P < .001$; Fig. 2). Proportions of *M. sanguinipes* and of all species of Melanoplinae combined were higher on the ungrazed sites (paired-sample t test, $P < .005$; Fig. 2). Oedipodinae showed a trend opposite that of the Melanoplinae, being found in greater proportions on the grazed sites (paired-sample t test, $P < .001$; Fig. 2). Proportions of Gomphocerinae were not affected by grazing (paired-sample t test, $P > 0.10$; Fig. 2).

Total grasshopper density was not correlated with any ground cover variables. Proportion of *M. sanguinipes* was negatively correlated with percentage bare ground and cover of perennial grasses ($r_s = -.59$ and $-.62$, respectively, $N = 30$, $P < .001$), and was positively correlated with percentage ground cover of cheatgrass and annual forbs ($r_s = .41$ and $.42$, respectively, $N = 30$, $P < .05$). Proportion of all Melanoplinae combined was correlated positively with cheatgrass ($r_s = .52$, $N = 30$, $P < .01$) and negatively with perennial grasses and percentage bare ground ($-.70$ and $-.64$, respectively, $N = 30$, $P < .001$).

As proportions of Melanoplinae declined with increasing cover of perennial grasses and bare ground, proportions of other species increased. Gomphocerinae showed trends opposite those of the Melanoplinae. Proportions of Gomphocerinae were correlated positively with perennial grasses and bare ground ($.66$ and $.46$, respectively, $N = 30$, $P < .01$) and negatively with cheatgrass and annual forbs ($-.52$ and $-.42$, respectively, $N = 30$, $P < .05$). Proportions of Oedipodinae were not significantly correlated ($P > .05$) with any of the ground cover variables.

DISCUSSION

Grazing influenced both total density and species composition of grasshoppers. Members of the subfamily Melanoplinae accounted for most of the increase in total density on ungrazed sites. Although vegetation did not affect density in this study, it strongly influenced species composition. Relative abundance of Gomphocerinae increased, and Melanoplinae decreased, with increasing coverage of perennial grasses and bare ground, while total numbers of grasshoppers remained the same. Proportions of *M. sanguinipes*, the primary pest species in the region, were negatively associated with grazing, perennial grasses (primarily crested wheatgrass), and percentage bare ground.

Habitat preferences of *M. sanguinipes*, or any organism, represent an integrated response to many stimuli. Short-term changes in habitat due to grazing may include reduced quantities of food, less escape space, increased amounts of bare ground, altered host plant quality, and changes in microhabitat temperature and

TABLE 3. Summary of Type III F-values (and significance levels) from three-way ANOVA for densities of total grasshoppers, *Melanoplus sanguinipes*, *Melanoplinae* other than *M. sanguinipes*, Gomphocerinae, and Oedipodinae.

Source	d.f.	Grasshopper density/m ²	Percentage <i>Melanoplus sanguinipes</i>	Percentage <i>Melanoplinae</i>	Percentage Gomphocerinae	Percentage Oedipodinae
Date (D)	2	12.9 (<.01)	18.7 (<.01)	11.9 (<.01)	21.3 (.01)	6.1 (<.01)
Vegetation type (V)	2	1.2 (.30)	19.3 (<.01)	29.3 (<.01)	22.2 (<.01)	5.6 (<.01)
Grazing (G)	1	5.6 (.02)	13.4 (<.01)	11.7 (<.01)	0.5 (.50)	8.8 (<.01)
V × D	4	2.1 (.09)	2.2 (.07)	2.8 (.03)	1.9 (.13)	1.2 (.34)
G × D	2	0.6 (.58)	0.3 (.77)	0.1 (.88)	2.1 (.13)	0.7 (.48)
V × G	2	0.7 (.49)	0.1 (.89)	0.1 (.87)	0.8 (.43)	0.9 (.43)
D × V × G	4	0.3 (.91)	0.6 (.69)	0.5 (.76)	0.2 (.96)	0.2 (.93)

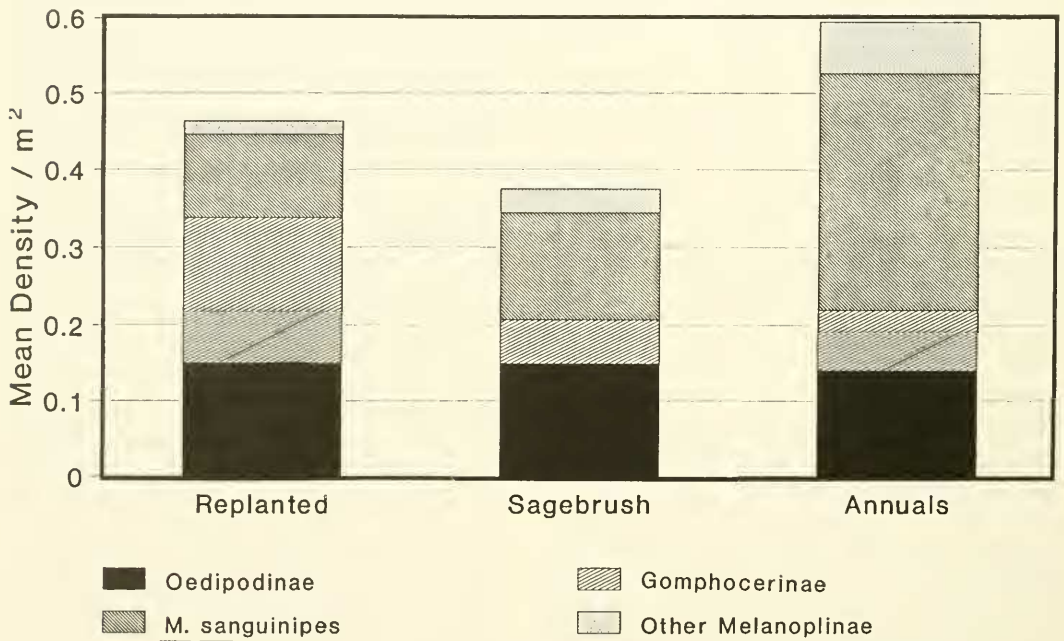


Fig. 1. Mean density of Oedipodinae, Gomphocerinae, *Melanoplinae* other than *Melanoplus sanguinipes*, and *M. sanguinipes* by vegetation type.

humidity. Differences in plant species composition between grazing treatments were minimal, indicating that long-term alteration of the plant community composition was probably not a factor.

Results of this study are consistent with some previous studies. Proportions of *M. sanguinipes* were negatively correlated with crested wheatgrass in this study. Fielding and Brusven (1992) demonstrated that crested wheatgrass is not a preferred host plant for *M. sanguinipes* in

southern Idaho. Perennial grasses are favored food plants for *Aulocara elliotti* (Pfadt 1949, Fielding and Brusven 1992), the most common gomphocerine in the study area. Proportions of *M. sanguinipes* were also negatively correlated with percentage bare ground. Nerney and Hamilton (1969) and Kemp and Sanchez (1987) reported that *M. sanguinipes* avoids oviposition in bare soil, whereas *A. elliotti* prefers to oviposit in bare ground (Kemp and Sanchez 1987, Fisher 1992). High percentages of bare

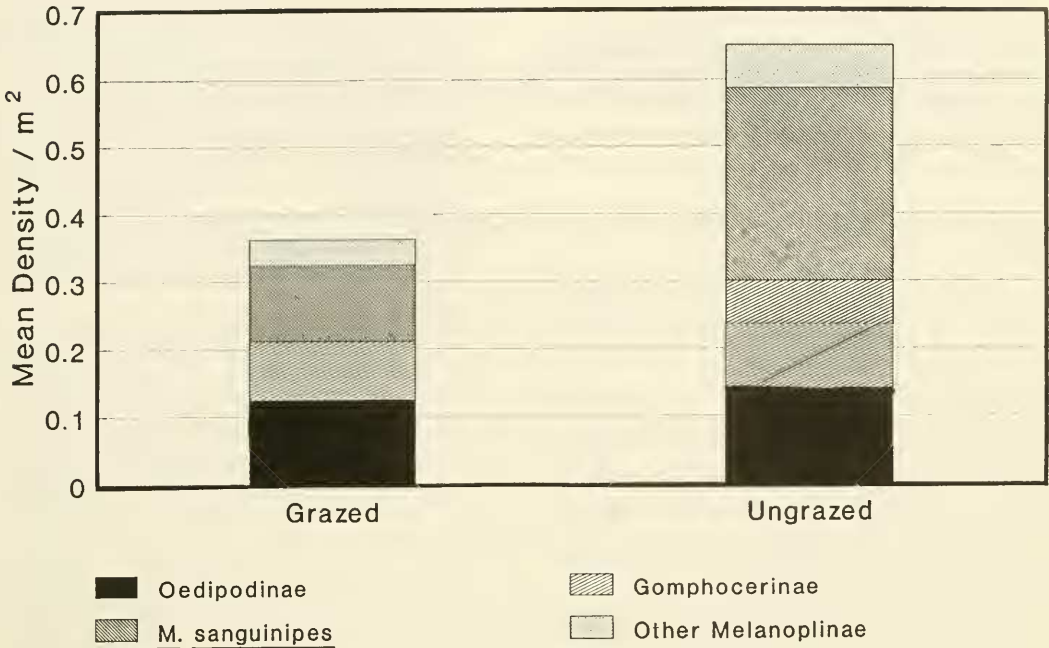


Fig. 2. Mean density of Oedipodinae, Gomphocerinae, Melanoplinae other than *Melanoplus sanguinipes*, and *M. sanguinipes* by grazing history.

ground were associated with both grazing and crested wheatgrass seedlings in the present study (Tables 1, 2).

Previous studies that examined grazing effects on grasshoppers reported results similar in some respects to those reported here. On the short-grass prairie of Colorado, Capinera and Sechrist (1982) reported that Oedipodinae were most abundant on the most heavily grazed pastures, while lightly grazed pastures supported the highest total grasshopper densities. Quinn and Walgenbach (1990) found Melanoplinae, particularly *Melanoplus sanguinipes*, to be dominant on ungrazed sites on mixed-grass prairies of South Dakota, even though total grasshopper abundance was less than on grazed sites. However, Miller and Onsager (1991) were unable to detect any effect of different grazing regimes on adult grasshopper populations, including *M. sanguinipes*, in a crested wheatgrass pasture in Montana.

Our observations were made under conditions of low grasshopper density and drought in southern Idaho. Fielding and Brusven (1990) showed that grasshopper population density in southern Idaho was positively correlated with precipitation. Results of this study cannot be extrapolated to predict how grasshopper

populations will respond to livestock grazing during more favorable years when rangeland productivity is high and grasshopper populations are rapidly expanding.

Rangeland grasshoppers have traditionally been viewed solely as destructive rangeland pests. However, in an ecosystem context they may have net beneficial worth during most years as an important food source for at least a part of the life cycle of many species of mammals, birds, and reptiles. Results presented here may serve as a cautionary note regarding rangeland ecosystem management under drought conditions. Grazing during years of drought and low grasshopper populations could conceivably add to the stress experienced by insectivorous animals by reducing available food resources (i.e., grasshopper populations), especially if other arthropods serving as alternate foods are also at low densities.

ACKNOWLEDGMENTS

We thank the staff of the BLM Shoshone District office for their support. J. A. Onsager, M. A. Quinn, and L. P. Kish reviewed earlier versions of the manuscript. William Price, statistical research associate, University of Idaho,

advised on statistical matters. Research was funded in part by Bureau of Land Management as Cooperative Agreement No. 919-CA7-05 and published with the approval of the director of the Idaho Agricultural Experiment Station as Paper No. 92731.

LITERATURE CITED

- CAMPBELL, J. B., W. H. ARNETT, J. D. LAMBLEY, O. K. JANTZ, AND H. KNUTSON. 1974. Grasshoppers (Acrididae) of the Flint Hills native tall grass prairie in Kansas. Kansas State University Agricultural Experiment Station Research Paper 19. 147 pp.
- CAPINERA, J. L., AND T. S. SECURIST. 1982. Grasshopper (Acrididae)-host plant associations: response of grasshopper populations to cattle grazing intensity. Canadian Entomologist 114: 1055-1062.
- COYNER, W. R. 1938. A report of the effect of overgrazing on the Acrididae. Proceedings of the Oklahoma Academy of Science 18: 83-85.
- DUNN, O. J. 1964. Multiple contrasts using rank sums. Technometrics 6: 241-252.
- FIELDING, D. J., AND M. A. BRUSVEN. 1990. Historical analysis of grasshopper (Orthoptera: Acrididae) population responses to climate in southern Idaho, 1950-1980. Environmental Entomology 19: 1786-1791.
- . 1992. Food and habitat preferences of *Melanoplus sanguinipes* and *Anlocara elliotti* (Orthoptera: Acrididae) on disturbed rangeland in southern Idaho. Journal of Economic Entomology 85: 783-788.
- FISHER, J. R. 1992. Location of egg pods of *Anlocara elliotti* (Orthoptera: Acrididae) in a field of crested wheatgrass in Montana. Journal of Kansas Entomology Society 65: 416-420.
- HOLMES, N. D., D. S. SMITH, AND A. JOHNSTON. 1979. Effect of grazing by cattle on the abundance of grasshoppers on fescue grassland. Journal of Range Management 32: 310-311.
- JEPSON-INNES, K., AND C. E. BOCK. 1989. Response of grasshoppers (Orthoptera: Acrididae) to livestock grazing in southeastern Arizona: differences between seasons and subfamilies. Oecologia 78: 430-431.
- KEMP, W. P., AND N. E. SANCHEZ. 1987. Differences in post-diapause thermal requirements for eggs of two rangeland grasshoppers. Canadian Entomologist 119: 653-661.
- MACK, R. N. 1981. Invasion of *Bromus tectorum* L. into western North America: an ecological chronicle. Agro-ecosystems 7: 145-165.
- MILLER, R. H., AND J. A. ONSAGER. 1991. Grasshopper (Orthoptera: Acrididae) and plant relationships under different grazing intensities. Environmental Entomology 20: 807-814.
- NERNEY, N. J., AND A. G. HAMILTON. 1969. Effects of rain-fall on range forage and populations of grasshoppers, San Carlos Apache Indian Reservation, Arizona. Journal of Economic Entomology 62: 329-333.
- ONSAGER, J. A. 1987. Current tactics for suppression of grasshoppers on range. Pages 60-66 in J. A. Onsager, editor, Integrated pest management on rangeland: state of the art in the sagebrush ecosystem. USDA-ARS, ARS-50.
- ONSAGER, J. A., AND J. E. HENRY. 1977. A method for estimating the density of rangeland grasshoppers (Orthoptera: Acrididae) in experimental plots. Acrida 6: 231-237.
- PELLANT, M., AND C. HALL. 1994. Distribution of two exotic grasses on intermountain rangelands: status in 1992. In: Proceedings—Symposium on ecology, management, and restoration of intermountain annual rangelands. USDA-FS, Intermountain Research Station, General Technical Report INT-GTR-313.
- PEADT, R. E. 1949. Food-plants, distribution, and abundance of the big-headed grasshopper, *Anlocara elliotti* (Thos.). Journal of the Kansas Entomological Society 22: 69-74.
- PICKFORD, G. D. 1932. The influence of continued heavy grazing and of promiscuous burning of spring-fall ranges in Utah. Ecology 13: 159-171.
- QUINN, M. A., AND D. D. WALGENBACH. 1990. Influence of grazing history on the community structure of grasshoppers of mixed-grass prairie. Environmental Entomology 19: 1756-1766.
- RICHARDS, O. W., AND N. WALOFF. 1954. Studies on the biology and population dynamics of British grasshoppers. Anti-locust Bulletin 17. London. 182 pp.
- SMITH, C. C. 1940. The effects of overgrazing and erosion upon the biota of the mixed grass prairie of Oklahoma. Ecology 21: 381-397.
- STEWART, G., AND A. C. HULL. 1949. Cheatgrass in southern Idaho. Ecology 30: 58-74.
- USDI-BLM. 1984. Proposed monument resource management plan and final environmental impact statement. USDI-Bureau of Land Management, Washington, DC.
- . 1990. Monument rangeland program summary. Progress report. USDI-Bureau of Land Management Shoshone District Office, Shoshone, ID.
- YENSEN, D. 1982. A grazing history of southwestern Idaho with emphasis on the Birds of Prey Study Area. Research project report. United States Department of the Interior, Bureau of Land Management, Boise, ID. 82 pp.
- ZAR, J. H. 1984. Biostatistical analysis. 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Received 30 March 1994

Accepted 10 April 1995